

FV3GFS -- Implementation Status & Workflow, Experiment Setup, Post-Processing, Verification

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Acknowledgment: Rahul Mahajan, George Gayno, Russ Treadon made significant contributions to the core of the workflow and utilities. Many other developers made contributions in the area of their expertise.



Topics



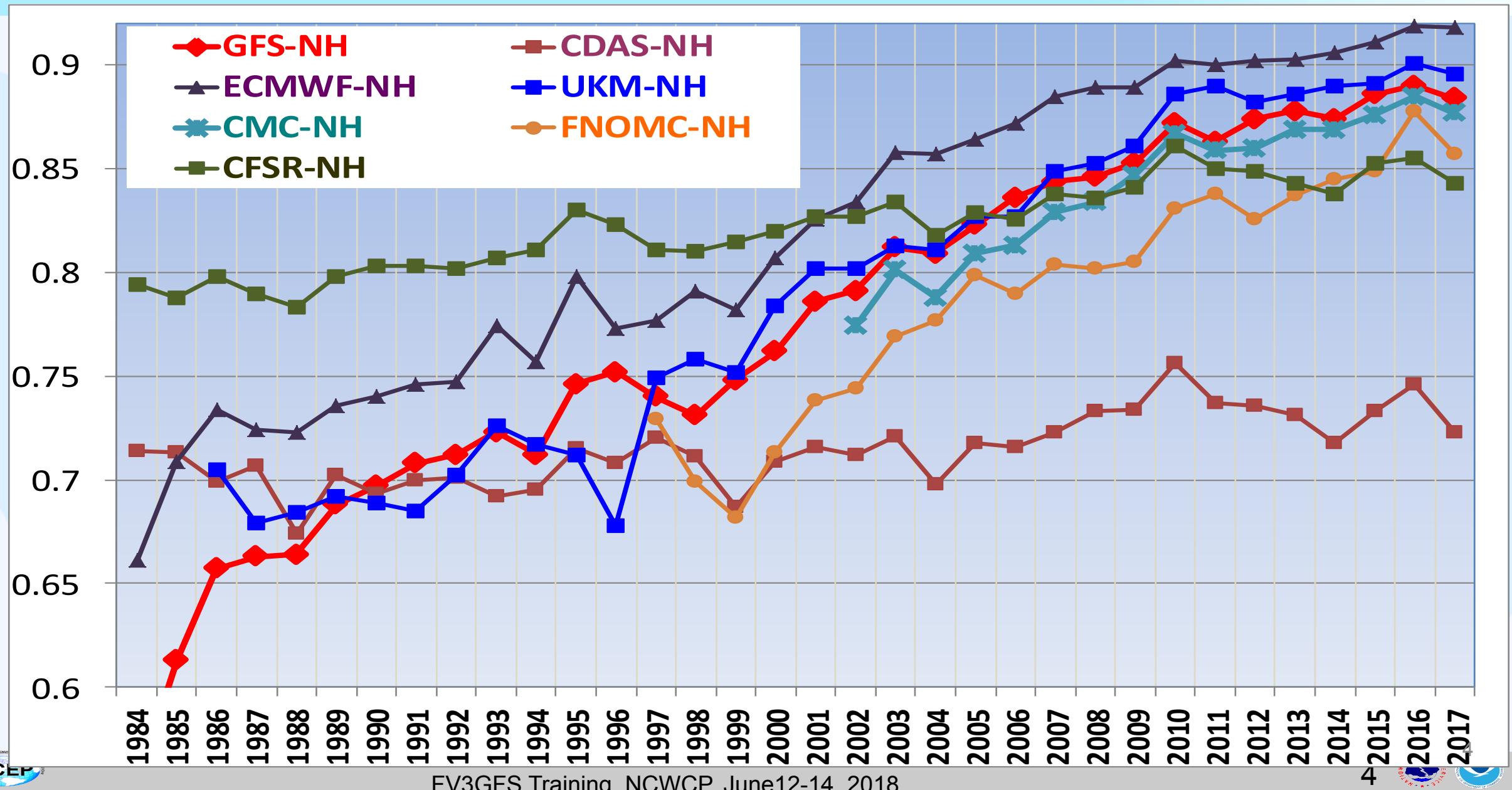
1. Upcoming FV3GFS implementation for operation
2. FV3GFS workflow and repositories
3. How to create grid and orography
4. How to make initial conditions
5. How to configure an experiment
6. Post processing and product generation
7. Verification



Change History of GFS Configurations

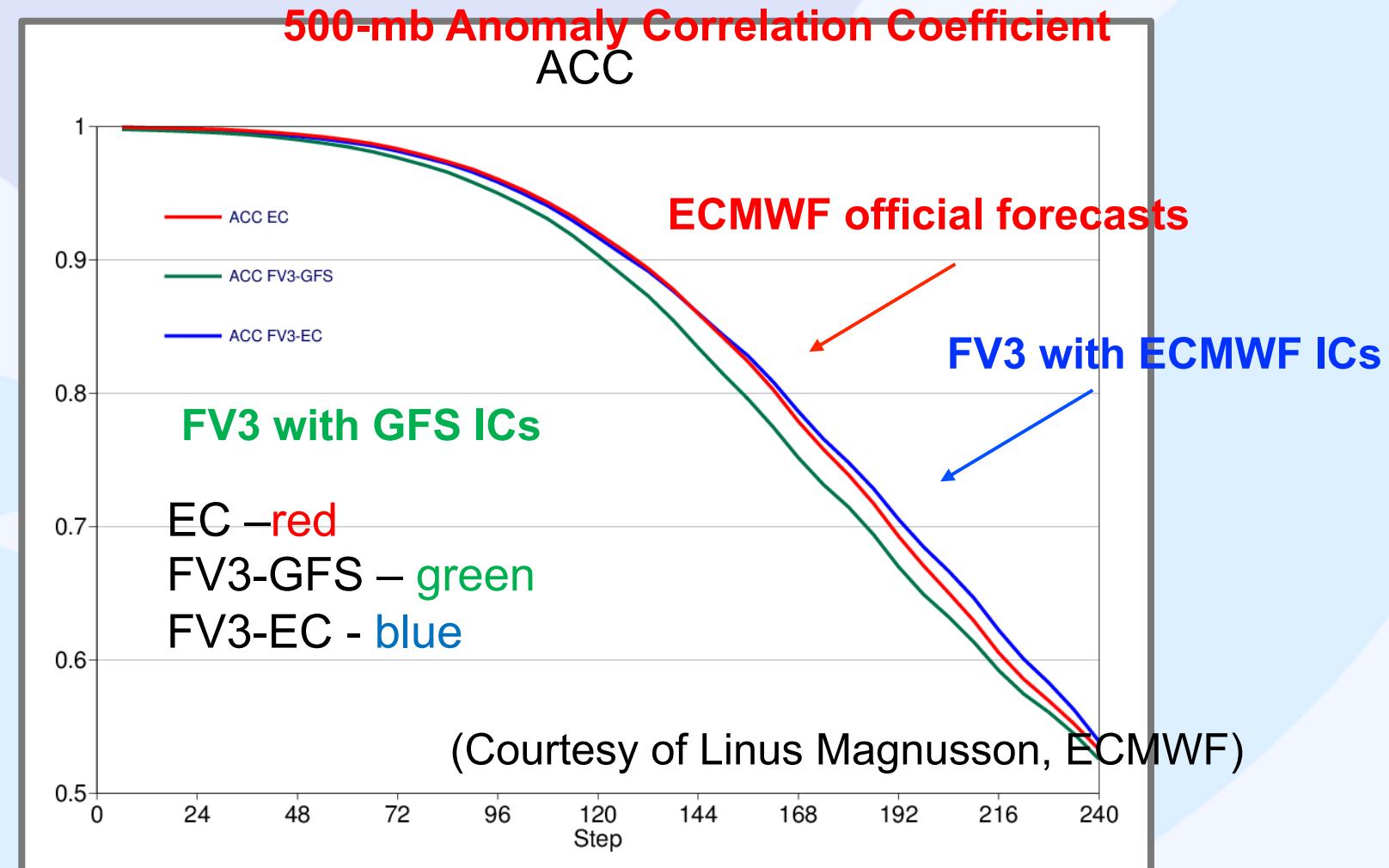
Mon/Year	Lev	Truncations	Z-cor/dyncore	Major components upgrade
Aug 1980	12	R30 (375km)	Sigma Eulerian	first global spectral model, rhomboidal
Oct 1983	12	R40 (300km)	Sigma Eulerian	
Apr 1985	18	R40 (300km)	Sigma Eulerian	GFDL Physics
Aug 1987	18	T80 (150km)	Sigma Eulerian	First triangular truncation; diurnal cycle
Mar 1991	18	T126 (105km)	Sigma Eulerian	
Aug 1993	28	T126 (105km)	Sigma Eulerian	Arakawa-Schubert convection
Jun 1998	42	T170 (80km)	Sigma Eulerian	Prognostic ozone; SW from GFDL to NASA
Oct 1998	28	T170 (80km)	Sigma Eulerian	the restoration
Jan 2000	42	T170 (80km)	Sigma Eulerian	first on IBM
Oct 2002	64	T254 (55km)	Sigma Eulerian	RRTM LW;
May 2005	64	T382 (35km)	Sigma Eulerian	2L OSU to 4L NOAH LSM; high-res to 180hr
May 2007	64	T382 (35km)	Hybrid Eulerian	SSI to GSI
Jul 2010	64	T574 (23km)	Hybrid Eulerian	RRTM SW; New shallow cnvtion; TVD tracer
Jan 2015	64	T1534 (13km)	Hybrid Semi-Lag	SLG; Hybrid EDMF; McICA etc
May 2016	64	T1534 (13km)	Hybrid Semi-Lag	4-D Hybrid En-Var DA
Jun 2017	64	T1534 (13km)	Hybrid Semi-Lag	NEMS GSM, advanced physics
JAN 2019	64	FV3 (13km)	Finite-Volume	NGGPS FV3 dycore, GFDL MP

Annual Mean NH 500hPa HGT Day-5 AC



SJ Lin showed us the potential. It is now up to us to make it happen

(August 2015 to August 2016, every 5th day = 73 cases)



First Version of NGGPS FV3GFS for Operation

FV3GFS is being configured to replace spectral model (NEMS GSM) in operations in Q2FY19

Configuration:

- FV3GFS C768 (~13km deterministic);
- FV3GDAS C384 (~25km, 80 member ensemble);
- 64 layer, top at 0.2 hPa;
- Uniform resolution for all 16 days
- Real-Time data made available through para-NOMADS
- FV3GFS evaluation entry page:
<http://www.emc.ncep.noaa.gov/users/Alicia.Bentley/fv3gfs>

Schedule:

- 3/7/18: code freeze of FV3GFS-V1 (GFS V15.0)
- 3/30/18: Public release of FV3GFS-V1 code
- 4/1 – 1/25/19: real-time EMC parallels
- 5/25 – 9/10/18: retrospectives and case studies (May 2015 – September 2018; three summers and three winters)
- 9/24/2018: Field evaluation due
- 9/27/2018: OD Brief, code hand-off to NCO
- 12/20/2018-1/20/2019: NCO 30-day IT Test
- 1/24/2019: Implementation

Real-time and retrospective parallels for evaluation

	Period	Machine	Status and comments
Real-time (Stream 0)	05/25/2018 ~ 01/24/2019	CRAY Prod	Running GFSMOS, GEMPAK, AWIPS, BUFRSND included
2017/18 Winter-Spring (Stream 1)	12/01/2017 ~ 05/31/2018	DELL	Running GFSMOS and BUFRSND included
2017 Summer-Fall (Stream 2)	06/01/2017 ~ 11/20/2017	CRAY Dev	Running GFSMOS and BUFRSND included
2016/17 Winter-Spring (Stream 3)	12/01/2016 ~ 05/31/2017	DELL	running
2016 Summer-Fall (Stream 4)	5/20/2016 ~ 11/30/2016	CRAY Dev	running
2015/16 Winter-Spring (Stream 5)	11/20/2015 ~ 05/31/2016	Gaea/Jet	In planning
2015 Summer-Fall (Stream 6)	5/01/2015 ~ 11/20/2015	DELL	running

Changes in Disk Usage -- one cycle

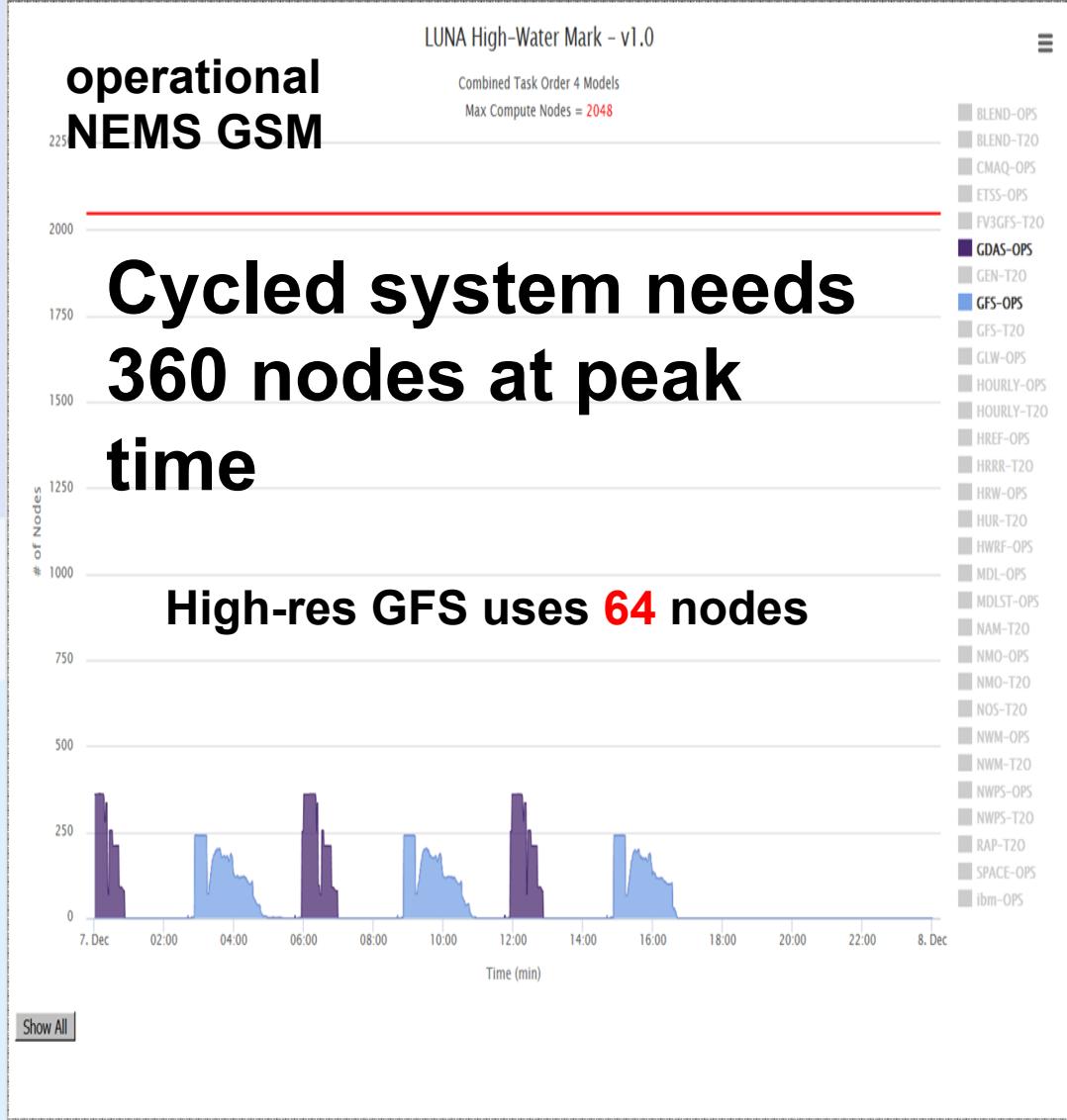
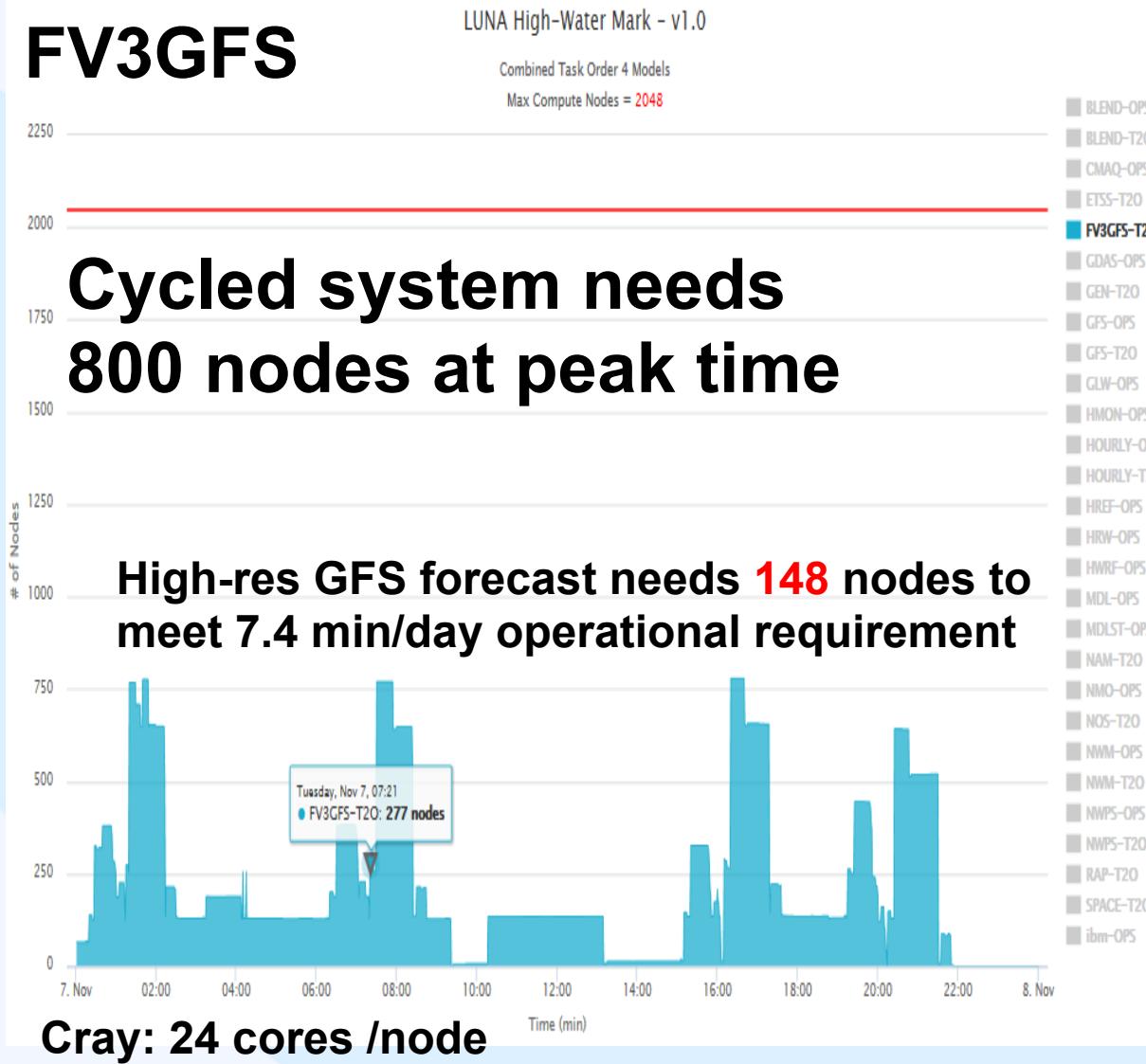
~130% increase

	anl+forecast	products & misc	total
ops gfs	1.70 TB	0.30 TB	2.0 TB
ops GDAS	0.157 TB	0.029 TB	0.186 TB
ops ENKF	1.831 TB	0.043 TB	1.874 TB
ops total			4.06 TB
FV3 GFS	2.91	0.30	3.21
FV3 GDAS	0.471	0.029	0.50
FV3 ENKF	5.493	0.043	5.536
FV3 total			9.246 TB

Ops GDAS and ENKF are run at T574 (1152x576), while FV3GFS is run at C384, e.g. T766 (1532x768). This is equivalent to a 77.7% increase in forecast file size. Factoring in the increase of output variables, **ENKF and GDAS file size will increase by 200%**.

Computation Resource Requirement -- HWM Test

FV3GFS



FV3GFS: Infrastructure and Physics Upgrades

- Integrated FV3 into **NEMS**
(national environmental Modeling System)
- Added **IPD** (interoperable physics driver) in **NEMSmfv3gfs**
- Newly developed **write grid component** -- write out model history file in native cubed sphere grid and Gaussian grid
- Replaced Zhao-Carr microphysics with the more advanced **GFDL microphysics**
- Updated parameterization of **ozone photochemistry** with additional production and loss terms (from NRL)
- New parameterization of middle atmospheric **water vapor photochemistry** (from NRL)
- a revised bare **soil evaporation scheme**.
- **Updated Stochastic** physics
- Improved **NSST** in FV3
- Use **GMTED2010 terrain** to replace TOPO30 terrain

Data Assimilation – GSI, Interfaces, and Observation

- Improved GSI efficiency
- Update GSI IO to ingest FV3GFS forecasts and provide analysis for FV3GFS.
- Update GSI to process additional cloud species from GFDL microphysics
- Compute increments of layer pressure and thickness hydrostatically from increments of surface pressure and temperature.
- Increase in ensemble resolution from roughly 39km to 25km.
- Adaptation of stochastic physics parameterizations from NEMS GSM with the exception of SKEB to provide model uncertainty estimate.
- Observations: add IASI moisture channels , ATMS all-sky radiances, Megha-Tropiques Saphir data, ASCAT data from MetOp-B, newNOAA-20 CrIS and ATMS data

Workflow Unification

- Almost all scripts adopted from the NEMS GFS were rewritten for the FV3GFS
- The old psub/pend job submission system is replaced by Rocoto drivers
- The 4-package superstructure workflow was merged into one package with a flat structure
- All JJOBS were rewritten. Both EMC parallels and NCO operation will use the same JJOBS
- EMC parallels and NCO operation follow the same file name convention and directory structure

An important achievement to simplify and unify the GFS suite between the development (EMC) and operation (NCO)

POST and Downstream Processing

- Precipitation products with both 6-hour bucket and continuous accumulation are provided
- Velocity from FV3GFS is dz/dt in m/s instead of omega in pa/s. Omega is diagnosed in the UPP and provided to users.
- More cloud hydrometers predicted by the advanced microphysics scheme are included in the products.
- Radar reflectivity derived using these new cloud hydrometers will also be added to GFS products.
- Height, pressure, and vertical velocity will be non-hydrostatic computed in model instead of being derived hydrostatically in Unified Post Processor.

This [Google Sheet](#) contains a complete list of product changes.

Evaluation Webpages

<http://www.emc.ncep.noaa.gov/users/Alicia.Bentley/fv3gfs>

Overall page

<http://www.emc.ncep.noaa.gov/gmb/emc.glopara/vsdb/prfv3rt1/>

real-time parallel

<http://www.emc.ncep.noaa.gov/gmb/emc.glopara/vsdb/fv3fy18retro2/>

2017 summer retro

<http://www.emc.ncep.noaa.gov/gmb/emc.glopara/vsdb/fv3fy18retro4>

2016 summer retro

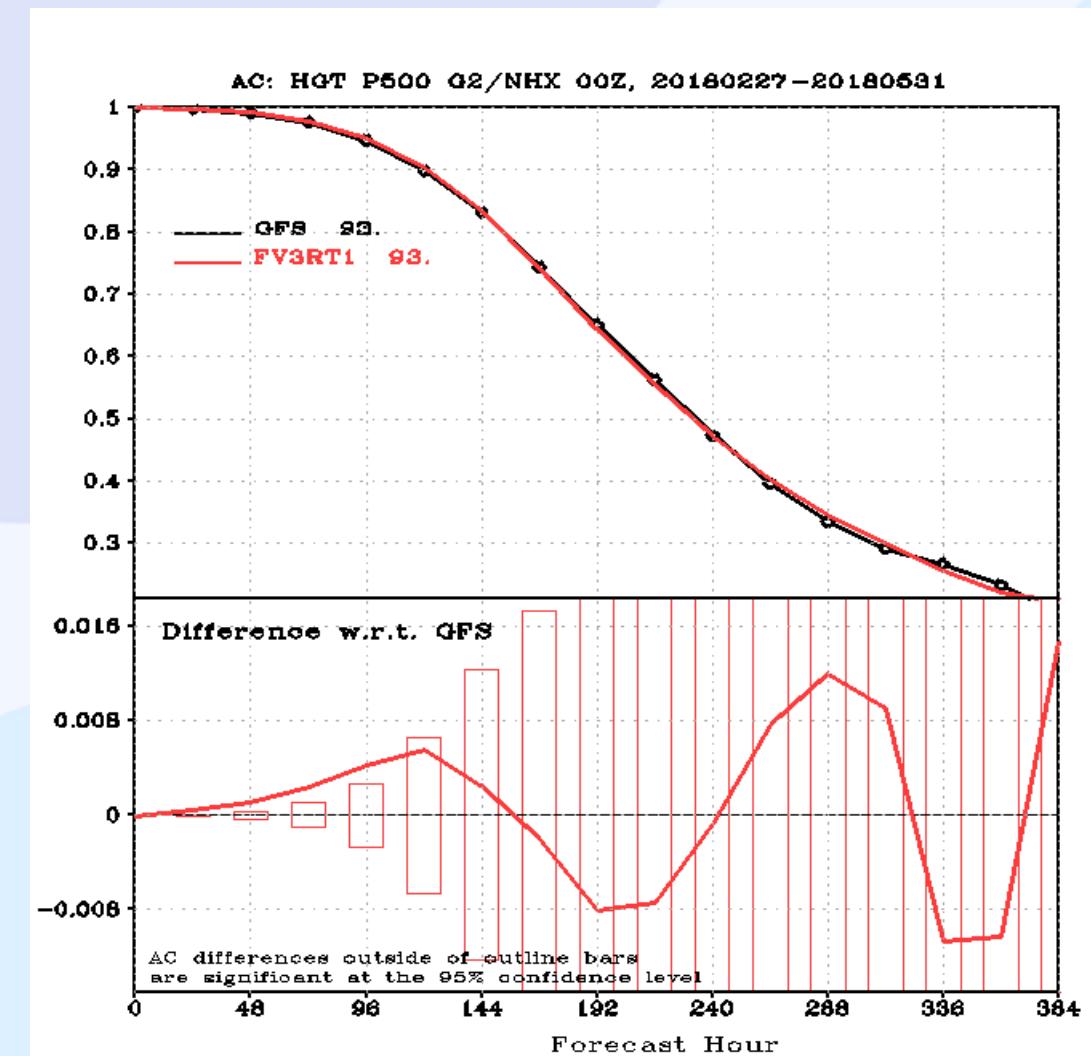
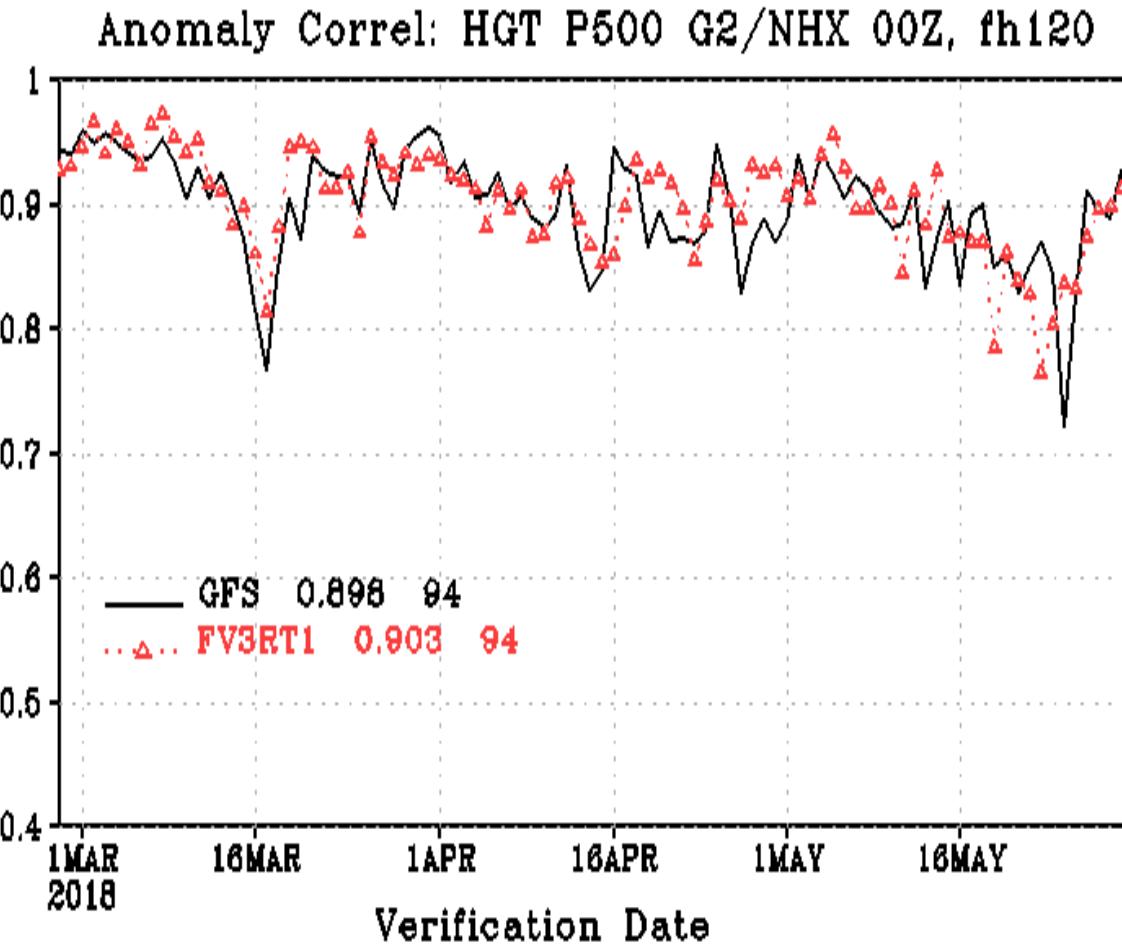
<http://www.emc.ncep.noaa.gov/mmb/ylin/pcpverif/scores.fv3/>

QPF

http://www.emc.ncep.noaa.gov/gc_wmb/tdorian/meg/index.html

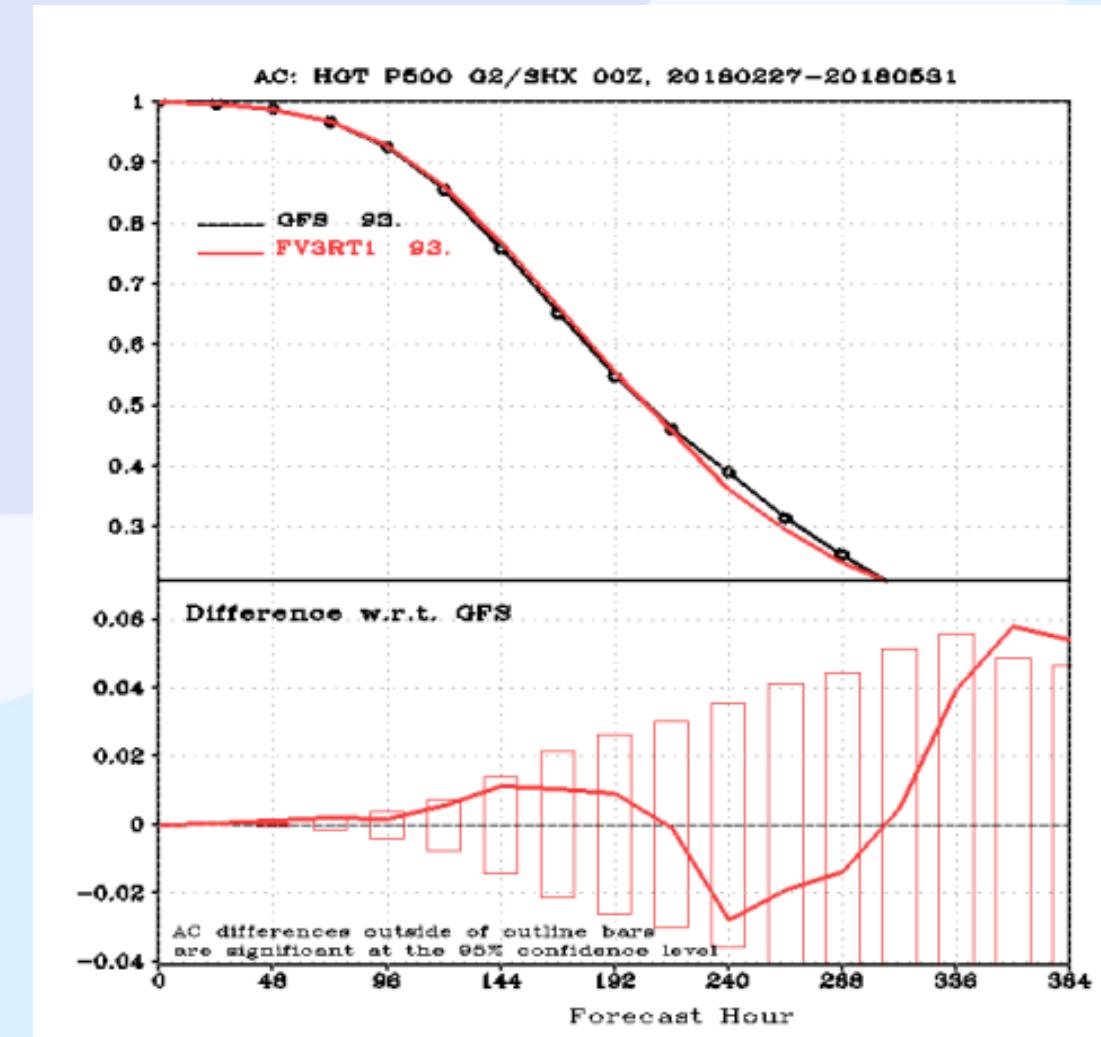
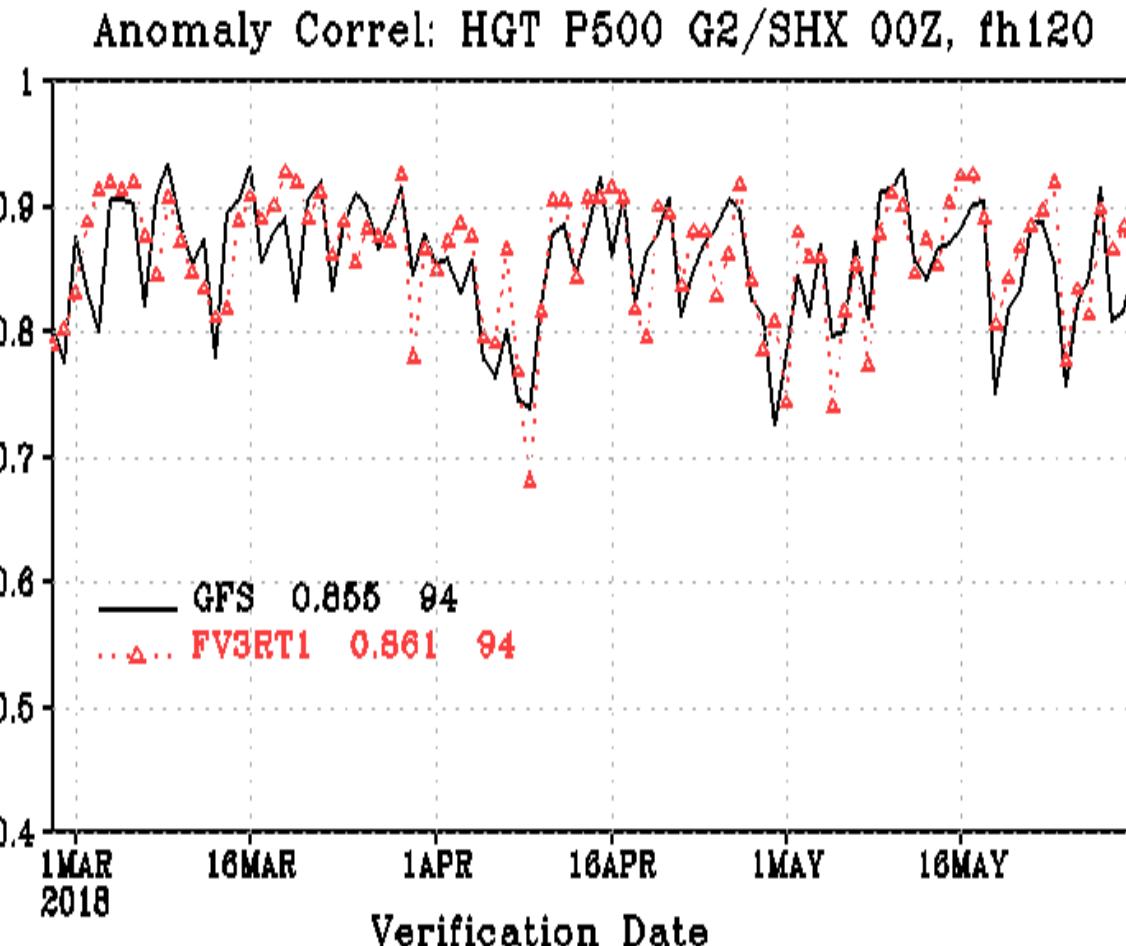
bufrsnd

Real-time experiments with fully cycled FV3GFS+GFDL MP NH 500-hPa HGT ACC (Spring 2018)



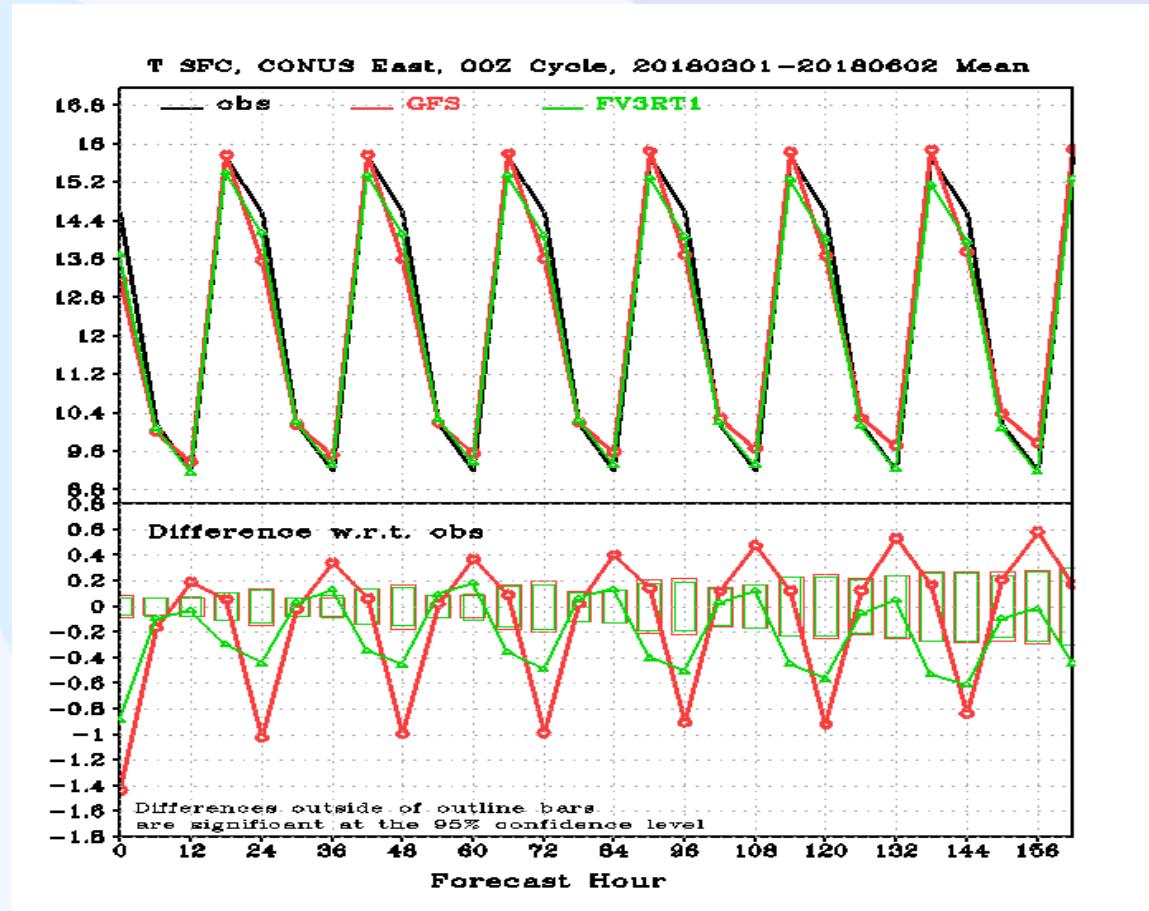
<http://www.emc.ncep.noaa.gov/gmb/emc.glopara/vsdb/prfv3rt1/>

Real-time experiments with fully cycled FV3GFS+GFDL MP SH 500-hPa HGT ACC (Spring 2018)

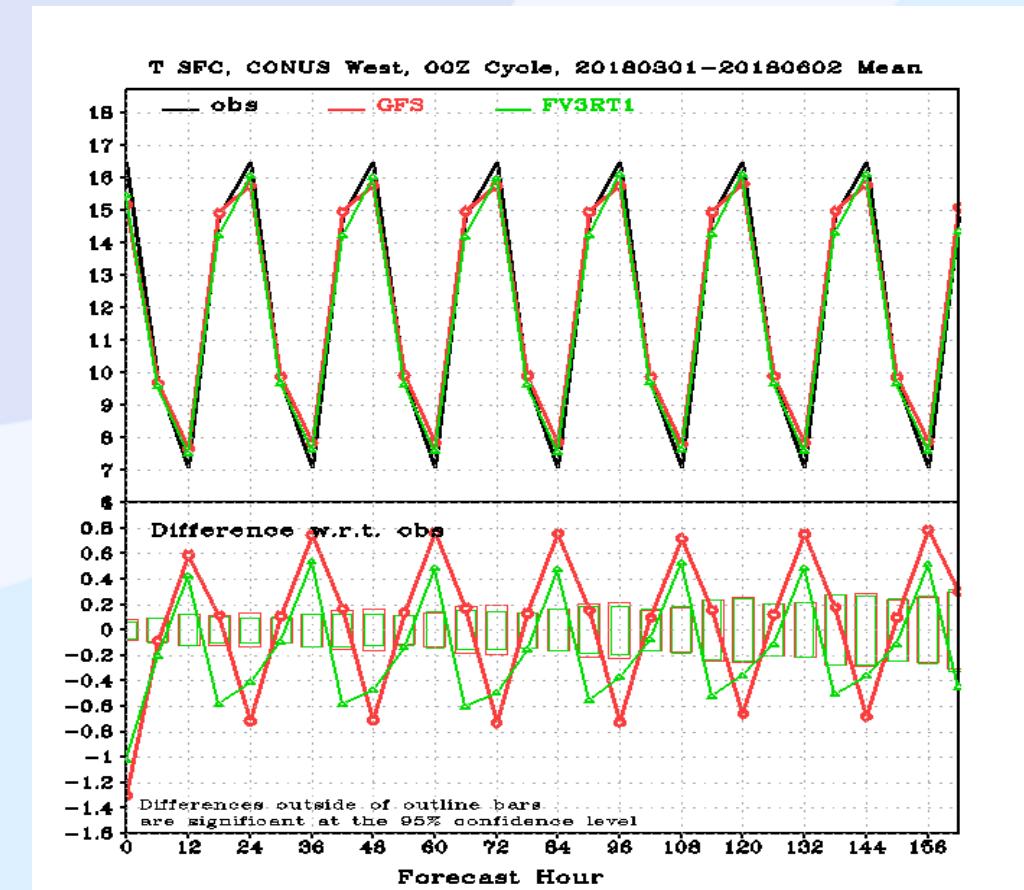


Real-time experiments with fully cycled FV3GFS+GFDL MP (Spring 2018)

T2m, fit to sfc Obs, CONUS East



T2m, fit to sfc Obs, CONUS West

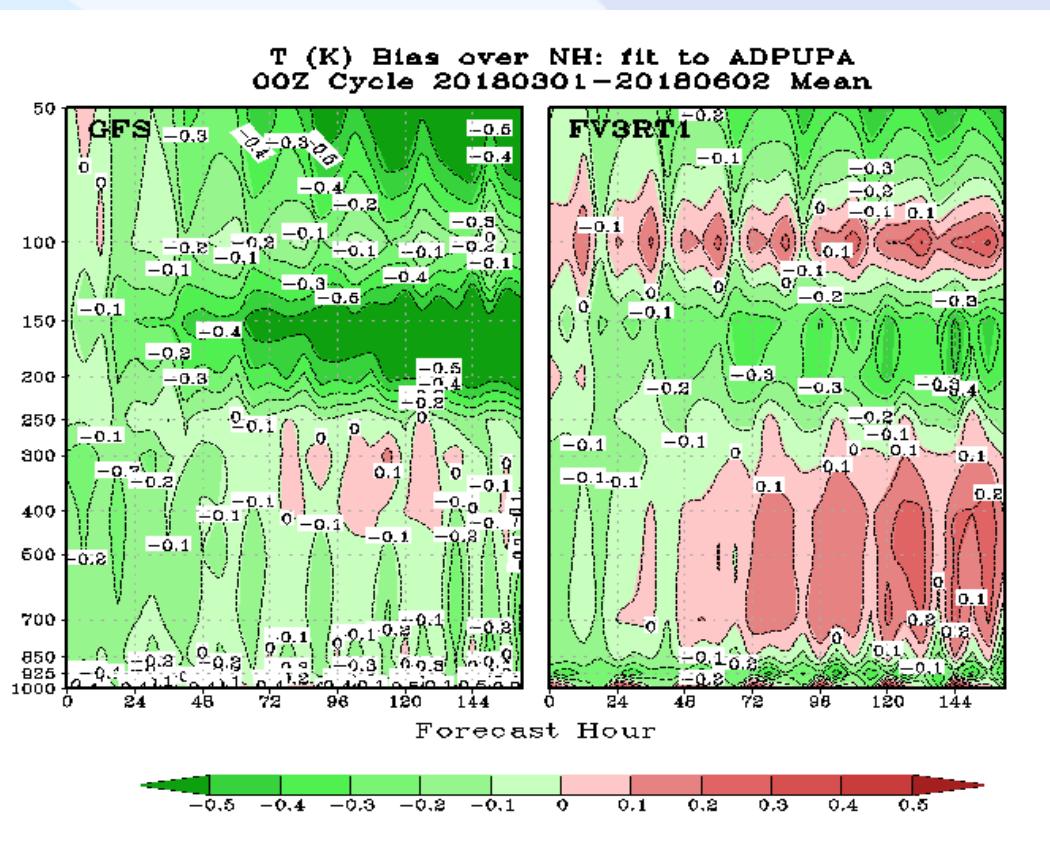


Slightly reduced T2m bias

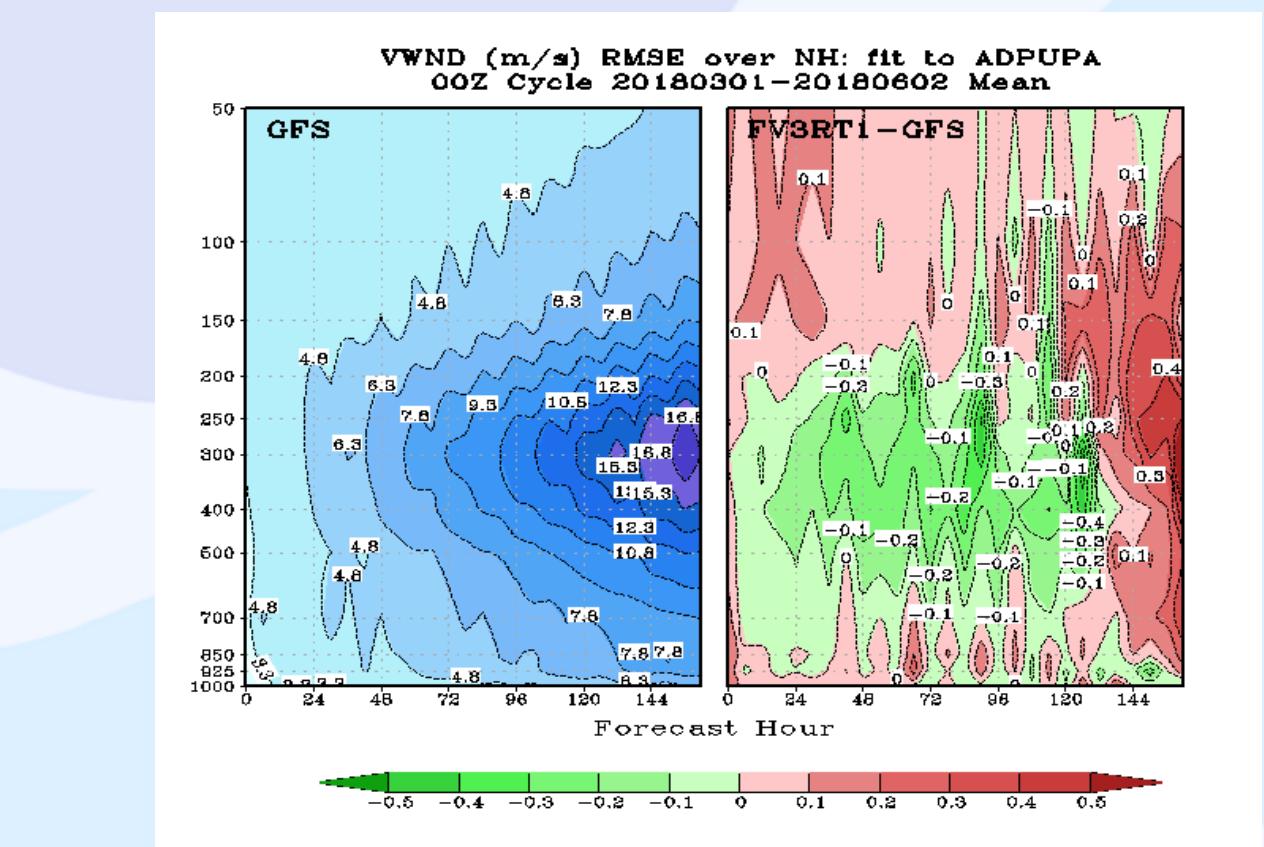
Real-time experiments with fully cycled FV3GFS+GFDL MP (Spring 2018)

http://www.emc.ncep.noaa.gov/gmb/emc.glopara/vsdb/prfv3rt1/g2o/g2o_00Z/index.html

NH Temp, fit to RAOBS



NH Wind RMSE, fit to RAOBS



- Reduced cold bias in the lower stratosphere and near the tropopause.
- Warm bias in the troposphere

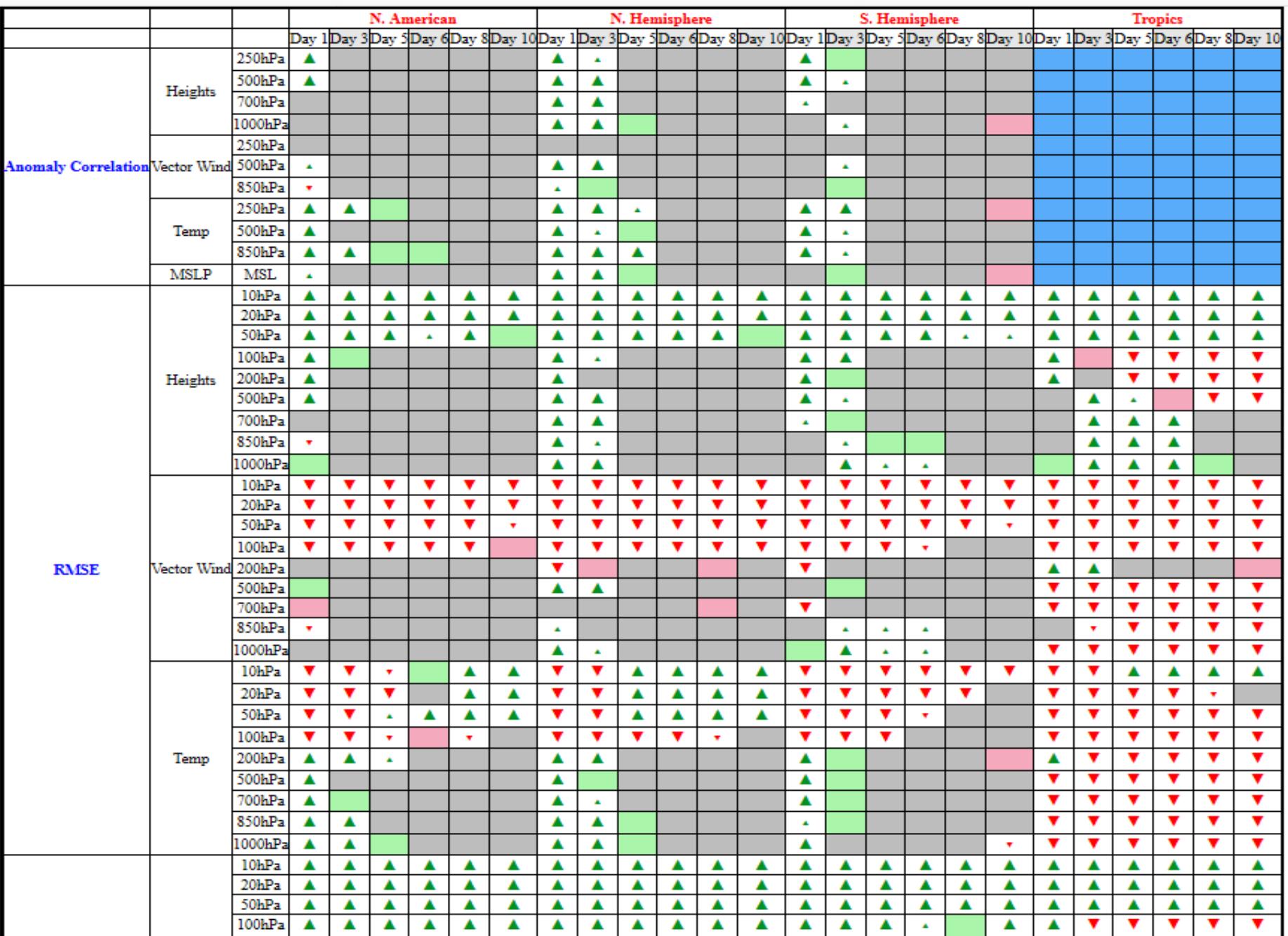
- Reduced wind RMSE in the troposphere up to 5 days. Slightly worse in the lower stratosphere

EMC Verification Scorecard	
Symbol Legend	
FV3RT1	better than GFS at the 99.9% significance level
FV3RT1	better than GFS at the 99% significance level
FV3RT1	better than GFS at the 95% significance level
No	statistically significant difference between FV3RT1 and GFS
FV3RT1	worse than GFS at the 95% significance level
FV3RT1	worse than GFS at the 99% significance level
FV3RT1	worse than GFS at the 99.9% significance level
Not	statistically relevant
Start Date: 20180226	
End Date: 20180530	

Scorecard

FV3GFS vs Operational GFS Spring 2018

Mostly neutral results



Topics

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- 2. **FV3GFS workflow and repositories**
- 3. How to create grid and orography
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FV3GFS workflow and external components

- FV3GFS Vlab Entry Page
<https://vlab.ncep.noaa.gov/group/fv3gfs>
- Workflow
<https://vlab.ncep.noaa.gov/redmine/projects/fv3gfs>
- NEMSFv3gfs (Infrastructure):
<https://vlab.ncep.noaa.gov/redmine/projects/nemsfv3gfs>
- FV3GFS Model (dynamics, physics, I/O, CAP)
<https://vlab.ncep.noaa.gov/redmine/projects/comfv3>
- GSI
<https://vlab.ncep.noaa.gov/redmine/projects/comgsi>
- POST
<https://vlab.ncep.noaa.gov/redmine/projects/emc-post>

Kate Friedman will explain in more detail

Checkout the system: for Cray/Dell/Theia Users

- `git clone --recursive gerrit:fv3gfs mycopy`
- `Cd mycopy/sorc`
- `Checkout.sh`
 - ▶ `git clone --recursive gerrit:NEMSFv3gfs fv3gfs.fd cd fv3gfs.fd`
 - ▶ `git checkout nemsfv3gfs_beta_v1.0.3`
 - ▶ `git clone --recursive gerrit:ProdGSI gsi.fd`
 - ▶ `git checkout fv3da.v1.0.14`
 - ▶ `git clone --recursive gerrit:EMC_post gfs_post.fd`
 - ▶ `git checkout ncep_post.v8.0.10`
- `Build_all.sh` (54 executables !)
- `link_fv3gfs.sh emclnco crayldellltheia`

If everything goes well, the entire system has now been set up.

Workflow Structure ./mycopy

[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util]

sorc

checkout.sh

awc_wafavn.fd	fv3nc2nemsio.fd	global_chgres.gfdl.fd	nemsio_read.fd
syndat_maksynrc.fd	cvgrib21_gfs.fd	gaussian_sfcanl.fd	global_cycle.fd
nst_tf_chg.fd	syndat_qctropcy.fd	emcsfc_ice_blend.fd	gdas_trpsfcmv.fd
gridbull.fd	orog.fd	tave.fd	emcsfc_snow2mdl.fd
getattr.fd	gsi.fd	overpdtg2.fd	regrid_nemsio.fd
enkf_chgres_recenter.fd	wintemv.fd	gfs_bufr.fd	mkgfsnemsioctl.fd
navybull.fd	gfs_post.fd	relocate_mv_nvortex.fd	
fre-nctools.fd	global_chgres.fd	nemsio_cvt.fd	supvit.fd
fv3gfs.fd		nemsio_get.fd	syndat_getjtbul.fd

38

build_all.sh

build_chgres.sh	build_fv3.sh	build_fv3nc2nemsio.sh	build_gfs_overpdtg2.sh	build_nems_util.sh
build_cycle.sh	build_gdas.sh	build_gfs_wintemv.sh	build_orog.sh	
build_emcsfc.sh	build_gfs_bufrsnd.sh	build_grib_util.sh	build_prod_util.sh	
build_enkf_chgres_recenter.sh	build_gfs_cvgrib21_gfs.sh	build_gsi.sh	build_regrid_nemsio.sh	
build_fre-nctools.sh	build_gfs_fbwndgfs.sh	build_libs.sh	build_sfcanl_nsttfchg.sh	
		build_ncep_post.sh	build_tropcy_NEMS.sh	

link_fv3gfs.sh

Workflow Structure ./mycopy

[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util]

modulefiles

gdas_gridbull.wcoss_cray	modulefile.global_emcsfc_ice_blend.wcoss_cray
gdas_navybull.wcoss_cray	modulefile.global_emcsfc_snow2mdl.wcoss_cray
gdas_trpsfcmv.wcoss_cray	modulefile.grib_util.wcoss_cray
gfs_bufr.wcoss_cray	modulefile.prod_util.wcoss_cray
gfs_cnvgrb21_gfs.wcoss_cray	modulefile.regrid_nemsio.wcoss_cray
gfs_fbwndgfs.wcoss_cray	modulefile.storm_reloc_v5.1.0.wcoss_cray
gfs_overpdtg2.wcoss_cray	modulefile.wgrib2.wcoss_cray
gfs_wintemv.wcoss_cray	module_nemsutil.wcoss_cray
module_base.wcoss_cray	wafs_v4.0.0.wcoss_cray
modulefile.fv3nc2nemsio.wcoss_cray	
fv3gfs/enkf_chgres_recenter.wcoss_cray	fv3gfs/gaussian_sfcanl.wcoss_cray
fv3gfs/fre-nctools.wcoss_cray	fv3gfs/global_chgres.wcoss_cray
	fv3gfs/global_cycle.wcoss_cray
	fv3gfs/orog.wcoss_cray

Defined for each platform: cray, dell, theia

Workflow Structure ./mycopy

[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util]

env

gfs.ver THEIA.env

```
export npe_node_max=28  
export launcher="mpirun -n"
```

```
export MPI_LABELIO=YES  
export MP_STDOUTMODE="ORDERED"  
export KMP_STACKSIZE=2048M  
export KMP_AFFINITY=scatter
```

```
.....  
elif [ $step = "anal" ]; then
```

```
    nth_max=$((npe_node_max / npe_node_anal))  
  
    export NTHREADS_GSI=${nth_gsi:-$nth_max}  
    [[ $NTHREADS_GSI -gt $nth_max ]] && export  
    NTHREADS_GSI=$nth_max  
    export APRUN_GSI="$launcher ${npe_gsi:-$npe_anal:-$PBS_NP}"  
.....
```

WCOSS_C.env

```
elif [ $step = "fcst" ]; then
```

```
    nth_max=$((npe_node_max / npe_node_fcst))  
  
    export NTHREADS_FV3=${nth_fv3:-$nth_max}  
    [[ $NTHREADS_FV3 -gt $nth_max ]] && export NTHREADS_FV3=$nth_max  
    export cores_per_node=npe_node_max  
    export APRUN_FV3="$launcher ${npe_fv3:-$npe_fcst:-$PBS_NP}"
```

```
    export NTHREADS_REGRID_NEMSIO=${nth_regrid_nemsio:-1}  
    [[ $NTHREADS_REGRID_NEMSIO -gt $nth_max ]] && export  
    NTHREADS_REGRID_NEMSIO=$nth_max  
    export APRUN_REGRID_NEMSIO="$launcher $LEVS"  
  
    export NTHREADS_REMAP=${nth_remap:-2}  
    [[ $NTHREADS_REMAP -gt $nth_max ]] && export NTHREADS_REMAP=$nth_max  
    export APRUN_REMAP="$launcher ${npe_remap:-$npe_fcst:-$PBS_NP}"
```

WCOSS_DELL_P3.env

Workflow Structure ./mycopy

[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util

fix

fix_am fix_fv3 fix_gsi gdas product **fix_fv3_gmted2010**

Symbolic links to local copies

....
global_soilmgladas.t1534.3072.1536.grb
global_lonsperlat.t1534.3072.1536.txt
global_orography_uf.t1534.3072.1536.rg.f77
global_soiltype.statsgo.t1534.3072.1536.grb
global_mtnvar.t1534.3072.1536.f77
global_orography_uf.t1534.3072.1536.rg.grb
....
global_mxsnoalb.uariz.t1534.3072.1536.rg.grb
global_slmask.t1534.3072.1536.rg.grb
global_orography.t1534.3072.1536.grb
global_snowfree_albedo.bosu.t1534.3072.1536.grb
.....

C768 C1152 C128 C192 C3072 C384 C48 C96

remap_weights_C768_0p25deg.nc
remap coefficients used by FREGRID

C768_grid.tile*.nc
title definition

C768_oro_data.tile*.nc
land-sea mask, orog, GWD variables etc

C768_mosaic.nc
connection between tiles

Workflow Structure ./mycopy

[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util]

parm

config parm_fv3diag post mon product relo wmo

config.anal config.fv3
config.arch config.fv3ic
config.awips config.gempak
config.base config.getic
config.base.nco config.nsst
config.earc config.post
config.ecen config.postsnd
config.efcs config.prep
config.eobs config.prepbufr
config.epos config.resources
config.eupd config.vrfy
config.fcst

diag_table diag_table_da
 define forecast output variables

field_table field_table_gfdl field_table_zhaocarr...
 define tracers for each MP scheme

data_table specify “override” data, e.g. SST etc

Configure files, define variables
common to all steps and those
unique to individual steps

diag_table

Users can add or removes variables in this table

Used by FMS and Write Grid Component

```
"fv3_history", 0, "hours", 1, "hours", "time"
"fv3_history2d", 0, "hours", 1, "hours", "time"

"gfs_dyn",    "ucomp",     "ugrd",      "fv3_history",  "all", .false., "none", 2
.....
"gfs_dyn",    "ps",        "pressfc",   "fv3_history",  "all", .false., "none", 2
"gfs_dyn",    "hs",        "hgtsfc",    "fv3_history",  "all", .false., "none", 2

"gfs_phys",   "ALBDO_ave",  "albdo_ave",   "fv3_history2d", "all", .false., "none", 2
.....
"gfs_phys",   "ULWRF",     "ulwrf_ave",   "fv3_history2d", "all", .false., "none", 2
"gfs_sfc",    "tref",       "tref",       "fv3_history2d", "all", .false., "none", 2
"gfs_sfc",    "z_c",        "zc",        "fv3_history2d", "all", .false., "none", 2
"gfs_sfc",    "c_0",        "c0",        "fv3_history2d", "all", .false., "none", 2
.....
##module_name", "field_name", "output_name", "file_name" "time_sampling", time_avg, "other_opts", packing
```

atmf\${fhr}.t\${cyc}.nemsio

sfcf\${fhr}.t\${cyc}.nemsio

Including all 2d
output, fluxes, and
nsst fields

Workflow Structure ./mycopy

[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util

ush

fv3gfs_chgres.sh

global_chgres_driver.sh

global_chgres.sh

fv3gfs_driver_grid.sh

fv3gfs_make_grid.sh

fv3gfs_make_orog.sh

fv3gfs_filter_topo.sh

global_cycle_driver.sh

global_cycle.sh

fv3gfs_remap.sh fv3gfs_remap_weights.sh fv3gfs_nc2nemsio.sh

Use fregrid to convert 6-tile netcdf to global lat-lon in nemsio. Primarily used before Write Grid Component was added to the model

fv3gfs_regrid_nemsio.sh

Jeff Whiatker et, convert 6-tile nc to Gaussian nemsio

hpssarch_gen.sh

Create HPSS archive list

emcsfc_ice_blend.sh
emcsfc_snow.sh
fix_precip.sh
fv3gfs_downstream_nems.sh
fv3gfs_driver_grid.sh
fv3gfs_dwn_nems.sh
fv3gfs_filter_topo.sh
fv3ics.py
gaussian_sfcanl.sh
getges.sh
gfs_bfr2gpk.sh
gfs_bufr.sh
gfs_ncepst.sh
gfs_postar1.sh
gfs_postar2.sh
gfe_ncep.sh
gfs_transfer.sh
gfs_truncate_enkf.sh
global_extrkr.sh
global_savefits.sh
global_tracker.sh
hpssarch_gen.sh
link_crtm_fix.sh
load_fv3gfs_modules.sh
minmon_xtrct_costs.pl
minmon_xtrct_gnorms.pl
minmon_xtrct_reduct.pl
mkbulk_ntc.sh
mkwfsqbl.sh
ozn_xtrct.sh
parse-storm-type.pl
radmon_ck_stdout.sh
radmon_err_rpt.sh
radmon_verf_angle.sh
radmon_verf_bcoef.sh
radmon_verf_bcosh.sh
radmon_verf_time.sh
rocoto
syndat_getjtbl.sh
syndat_qctropcy.sh
trim_nh.sh
tropcy_relocate_extrkr.sh
tropcy_relocate.sh
wafs_intdsk.sh
WAM_XML_to_ASCII.pl

Workflow Structure ./mycopy

```
[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util]
```

ush/rocoto

setup_expt_fcstonly.py

setup_expt.py

workflow_utils.py

setup_workflow_fcstonly.py

setup_workflow.py

rocoto.py

rocoto_viewer.py

Fcst-only

cycled

Rocoto-based workflow scheduler, creates runtime expdir, config.base and xml file

See Kate Frideman's presentation

Workflow Structure ./mycopy

[docs driver env exec fix gempak jobs modulefiles parm scripts sorc ush util]

Jobs/rocoto

anal.sh awips.sh ecen.sh eobs.sh epos.sh **fcst.sh** gempak.sh post.sh prep.sh
arch.sh earc.sh efcs.sh eomg.sh eupd.sh fv3ic.sh getic.sh postsnd.sh vrfy.sh

All jobs for
an end-to-
end system

Jobs

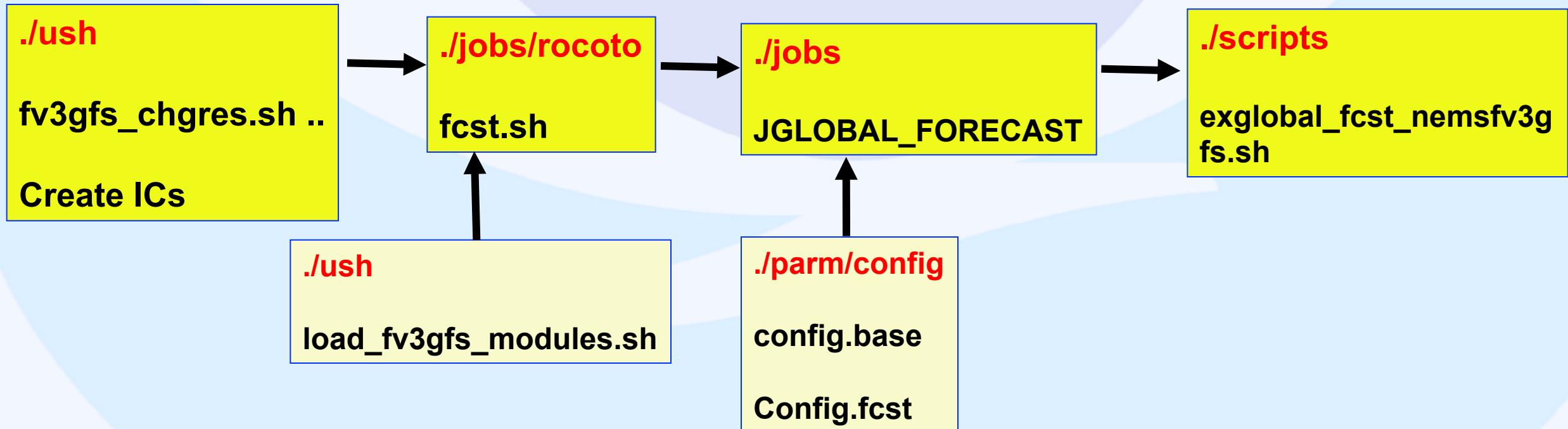
JGDAS_BULLS_NAVY JGDAS_TROPC JGFS_CYCLONE_GENESIS JGFS_POST SND JGLOBAL_ENKF_SELECT_OBS rocoto
JGDAS_ENKF_FCST JGDAS_VERFOZN JGFS_CYCLONE_TRACKER JGFS_PRDGEN_MANAGER JGLOBAL_ENKF_UPDATE
JGDAS_ENKF_POST JGDAS_VERFRAD JGFS_FAX JGFS_VMINMON **JGLOBAL_FORECAST**
JGDAS_ENKF_RECENTER JGDAS_VMINMON JGFS_FBWIND JGLOBAL_ANALYSIS JGLOBAL_NCEPPOST
JGDAS_GEMPAK JGFS_AWIPS_20KM_1P0DEG JGFS_GEMPAK JGLOBAL_EMCSFC_SFC_PREP JGLOBAL_POST_MANAGER
JGDAS_GEMPAK_META_NCDC JGFS_AWIPS_G2 JGFS_GEMPAK_NCDC_UPAPGIF JGLOBAL_ENKF_INNOVATE_OBS
JGLOBAL_TROPACY_QC_RELOC

scripts

exgdas_ncep post.sh.ecf exgfs_ncep post.sh.ecf exgfs_postsnd.sh.ecf
exglobal_analysis_fv3gfs.sh.ecf exglobal_enkf_fcst_fv3gfs.sh.ecf
exglobal_enkf_innovate_obs_fv3gfs.sh.ecf exglobal_enkf_post_fv3gfs.sh.ecf
exglobal_enkf_recenter_fv3gfs.sh.ecf exglobal_enkf_update_fv3gfs.sh.ecf
exglobal_fcst_nemsv3gfs.sh exglobal_innovate_obs_fv3gfs.sh.ecf

how are the different components connected ?

Taking forecast as an example



Most users only need to modify these two config files

Topics

- x 1. Upcoming FV3GFS implementation for operation
- x 2. FV3GFS workflow and repositories
- x 3. **How to create grid and orography**
- x 4. How to make initial conditions
- x 5. How to configure an experiment
- x 6. Post processing and product generation
- x 7. Verification

ush

fv3gfs_driver_grid.sh
fv3gfs_make_grid.sh **fv3gfs_make_orog.sh** **fv3gfs_filter_topo.sh**

sorc

fre-nctools.fd **orog.fd**

fv3gfs_driver_grid.sh --- works on Cray and Theia

```
# Makes FV3 cubed-sphere grid
export res=96          # resolution of tile: 48, 96, 128, 192, 384, 768, 1152, 3072
export gtype=uniform    # grid type: uniform, stretch, nest or regional

if [ $gtype = uniform ]; then
  echo "creating uniform ICs"
elif [ $gtype = stretch ]; then
  export stretch_fac=1.5 # Stretching factor for the grid
.....
elif [ $gtype = nest ] || [ $gtype = regional ]; then
.....
  export target_lon=-97.5 # center longitude of the highest resolution tile
.....

$script_dir/fv3gfs_make_grid.sh $res $grid_dir $script_dir
$script_dir/fv3gfs_make_orog.sh $res $tile $grid_dir $orog_dir ..... $TMPDIR
$script_dir/fv3gfs_filter_topo.sh $res $grid_dir $orog_dir $filter_dir .....
```

Output Dir

**./fix/
fix_fv3_gmted2010**

Topics

1. Upcoming FV3GFS implementation for operation
2. FV3GFS workflow and repositories
3. How to create grid and orography
4. **How to make initial conditions**
5. How to configure an experiment
6. Post processing and product generation
7. Verification

ush**fv3gfs_chgres.sh****global_chgres_driver.sh****global_chgres.sh****sorc****global_chgres.fd****nst_tf_chg.fd****fv3gfs_chgres.sh --- works on Cray, Dell, and Theia**

This script calls ./ush/global_chgres_driver.sh to create **high-res** and/or **enkf 80-member cold start initial conditions**, and stages all necessary DA files for starting a **forecast-only** or **cycled** fv3gfs experiment.

```
export PSLOT=fv3test
export CDUMP=gdas
export CASE_HIGH=C192
export CASE_ENKF=C96
export CDATE=2018050100
export CDUMP=gdas
(gdas /gfs )
```

```
export NSTSMTH=YES
## apply 9-point smoothing to nsst tref
export ZERO_BIAS=YES
## zeroed out all bias and radsat files
```

Input analysis options

1. Online real-time operational NEMS GFS
2. HPSS archive of operational GFS after 20170720
3. HPSS archive of Q3FY17 NEMS GSM retrospective parallels, 20140501 through 20170720

output /gpfs/dell3/ptmp/emc.glopara/fv3test

```
[emc.glopara@v71a2 fv3q2fy19retro5]$ ls */
enkf.gdas.20151125/00:
mem001 mem008 mem015 mem022 mem029 mem036
mem043 .....
gdas.20151125/00:
gdas.t00z.abias gdas.t00z.radstat INPUT
gdas.t00z.abias_air gdas.t00z.abias_pc
```

Topics

- 1. Upcoming FV3GFS implementation for operation
- 2. FV3GFS workflow and repositories
- 3. How to create grid and orography
- 4. How to make initial conditions
- 5. **How to configure an experiment**
- 6. Post processing and product generation
- 7. Verification

```
$HOMEgfs/ush/rocoto/setup_expt.py \  
  --pslot $PSLOT \  
  --configdir $HOMEgfs/parm/config \  
  --idate $IDATE \  
  --edate $EDATE \  
  --resdet $RESDET \  
  --resens $RESENS \  
  --comrot $COMROT \  
  --expdir $EXPDIR \  
  --cdump $CDUMP \  
  --ickdir $ICSDIR\  
  --gfs_cyc $gfs_cyc \  
  --nens 80
```

```
$HOMEgfs/ush/rocoto/setup_workflow.py  
  --expdir $EXPDIR/$PSLOT
```

/gpfs/dell2/emc/modeling/noscrub/Fanglin.Yang/
para_gfs/fv3test

config.anal config.base.nco config.nobs config.fv3
config.nsst config.prepbufr config.eas config.epos config.fv3ic
config.arch config.eas config.epos config.fv3ic
config.post config.sources config.eupd
config.awips config.scen config.eupd
config.gempak config.postsnd config.vrfy
config.base config.efcs config.fcst config.getic
config.prep

fv3test.xml

rocotorun -d fv3test.db -w fv3test.xml

What's inside config.base ?

```
export machine="WCOSS_DELL_P3"
```

```
export RUN_ENVIR="emc"
```

```
HOMEgfs=/gpfs/dell2/.... Workflow "mycopy"
```

```
Stmp, ptmp, homedir, savedir, noscrub etc
```

```
export FHMIN_GFS=0  
export FHMAX_GFS_00=384  
export FHMAX_GFS_06=180  
export FHMAX_GFS_12=180  
export FHMAX_GFS_18=180
```

```
export FHOUT_GFS=3  
export FHMAX_HF_GFS=0  
export FHOUT_HF_GFS=1
```

```
export QUILTING=".true."  
export OUTPUT_GRID="gaussian_grid"  
export OUTPUT_FILE="nemsio"
```

```
# Microphysics Options: 99-ZhaoCarr, 8-Thompson; 6-  
WSM6, 10-MG, 11-GFDL  
export imp_physics=11
```

```
# Hybrid related  
export DOHYBVAR="YES"  
export NMEM_ENKF=80  
export SMOOTH_ENKF="YES"  
export l4densvar=".true."  
export lwrite4danl=".false."
```

```
INCREMENTS_TO_ZERO="delz_inc','clwmr_inc','icmr_inc"
```

```
# Archiving options  
export HPSSARCH="YES"  
export ARCH_CYC=00  
export ARCH_WARMICFREQ=1  
export ARCH_FCSTICFREQ=1
```

How to change forecast model computing nodes, threads etc ?

config.fv3

```
"C768")
  export DELTIM=225
  export layout_x=8
  export layout_y=16
  export npe_node_fcst=12
  export nth_fv3=2
  export cdmbgwd="3.5,0.25"
  export WRITE_GROUP=4
  export WRTTASK_PER_GROUP=60
  export WRTIOBUF="32M"
```

Computing Nodes = layout_x * layout_y * 6 / npe_node_fcst=12

I/O Nodes = WRITE_GROUP* WRTTASK_PER_GROUP / npe_node_fcst=12

How to change computing resource for other steps ?

config.resources

```
if [ $step = "prep" -o $step = "prepbufr" ]; then  
  
    eval "export wtime_$step='00:45:00"  
    eval "export npe_$step=4"  
    eval "export npe_node_$step=4"  
    eval "export nth_$step=4"  
  
elif [ $step = "anal" ]; then  
  
    export wtime_anal="02:30:00"  
    export npe_anal=490  
    export npe_node_anal=7  
    export nth_anal=4  
    if [[ "$machine" == "WCOSS_C" ]]; then  
        export memory_anal="3072M"  
    fi
```

```
elif [ $step = "fcst" ]; then  
  
    export wtime_fcst="01:00:00"  
    export wtime_fcst_gfs="06:00:00"  
    export npe_fcst=$(echo "$layout_x * $layout_y * 6" |  
bc)  
    export npe_node_fcst=${npe_node_fcst:-12}  
    export nth_fcst=2  
    if [[ "$machine" == "WCOSS_C" ]]; then  
        export memory_fcst="1024M"  
    fi  
  
elif [ $step = "post" ]; then  
  
    export wtime_post="02:00:00"  
    export wtime_post_gfs="06:00:00"  
    export npe_post=84  
    export nth_post=1  
    export npe_node_post=14  
    export npe_node_dwn=28  
  
....  
fi
```

How to change forecast options ?

config.fcst

```
# Model configuration
export TYPE="nh"
export MONO="non-mono"

# Use stratosphere h2o physics
export h2o_phys=".true."

# Options of stratosphere O3 physics reaction coefficients
export new_o3forc="YES"

# Microphysics configuration
export dnats=0
export cal_pre=".true."
export do_sat_adj=".false."
export random_clds=".true."

if [ $imp_physics -eq 99 ]; then # ZhaoCarr MP
    export ncll=1
...
    export nwat=2
```

```
.....
elif [ $imp_physics -eq 11 ]; then # GFDL MP
    export ncll=5
    export FIELD_TABLE="$HOMEgfs/parm/parm_fv3diag/
field_table_gfdl"
    export nwat=6
    export dnats=1
    export cal_pre=".false."
    export do_sat_adj=".true."
    export random_clds=".false.

    export hord_mt_nh_nonmono=6
    export hord_xx_nh_nonmono=6
    export vtdm4_nh_nonmono=0.02
    export nord=2
    export dddmp=0.1
    export d4_bg=0.12

.....
```

Where are the default forecast namelist options and fixed fields defined ?

exglobal_fcst_nemsv3gfs.sh

Fix files

```
FNGLAC=${FNGLAC:-"$FIX_AM/global_glacier.2x2.grb"}  
FNMXIC=${FNMXIC:-"$FIX_AM/global_maxice.2x2.grb"}  
FNTSFC=${FNTSFC:-"$FIX_AM/RTGSST.1982.2012.monthly.clim.grb"}  
FNSNOC=${FNSNOC:-"$FIX_AM/global_snoclim.1.875.grb"}  
FNZORC=${FNZORC:-"igbp"}  
FNALBC2=${FNALBC2:-"$FIX_AM/global_albedo4.1x1.grb"}  
FNAISC=${FNAISC:-"$FIX_AM/CFSR.SEAICE.1982.2012.monthly.clim.grb"}  
FNTG3C=${FNTG3C:-"$FIX_AM/global_tg3clim.2.6x1.5.grb"}
```

```
rm -f model_configure  
cat > model_configure <<EOF  
total_member: $ENS_NUM  
print_esmf: ${print_esmf:-.true.}  
PE_MEMBER01: $NTASKS_FV3  
start_year: $SYEAR  
start_month: $SMONTH  
start_day: $SDAY  
start_hour: $SHOUR  
.....
```

&fv_core_nml

```
layout = $layout_x,$layout_y  
io_layout = $io_layout  
npx = $npx  
npy = $npy  
ntiles = $ntiles  
npz = $npz  
grid_type = -1  
make_nh = $make_nh  
fv_debug = ${fv_debug:-.false.}  
range_warn = ${range_warn:-.false.}  
reset_eta = .false.  
.....
```

&gfs_physics_nml

```
fhzero = $FHZER  
h2o_phys = ${h2o_phys:-.true.}  
ldiag3d = ${ldiag3d:-.false.}  
fhcyc = $FHCYC  
use_ufo = ${use_ufo:-.true.}  
pre_rad = ${pre_rad:-.false.}  
ncld = ${ncld:-1}  
imp_physics = ${imp_physics:-"99"}  
pdfcld = ${pdfcld:-.false.}  
.....
```

General users: Do not change this script. Almost all default values can be defined in config files

<code>rocotostat -d fv3test.db -w fv3test.xml -c 2018060100 -t all</code>	check status
<code>Rocotorewind -d fv3test.db -w fv3test.xml -c 2018060100 -t gfsfcst</code>	rewind a dead job
<code>Rocotoboot -d fv3test.db -w fv3test.xml -c 2018060100 -t gfsfcst</code>	boot a live job
<code>rocotorun -d fv3test.db -w fv3test.xml</code>	running jobs

CLE	TASK	JOBID	STATE	EXIT	TRIES	DURATION	SLOTS	QTIME	CPU	RUN
===== (updated: 2018-06-14 05:59) =====										
201712280600	gdasprep	444204	SUCCEEDED	0	1	309	-	-	-	-
201712280600	gdasanal	444379	SUCCEEDED	0	1	2826	-	-	-	-
201712280600	gdasfcst	444518	SUCCEEDED	0	1	429	-	-	-	-
201712280600	< gdaspst	444537	(6/6) SUCCEEDED	0	1	104	-	-	-	-
201712280600	gdasvrfy	444560	SUCCEEDED	0	1	130	-	-	-	-
201712280600	gdasarch	444574	SUCCEEDED	0	1	4385	1	0	2340	4385
201712280600	gdaseobs	444380	SUCCEEDED	0	1	167	-	-	-	-
201712280600	< gdaseomn	444391	(8/8) SUCCEEDED	0	1	803	-	-	-	-
201712280600	gdaseupd	444519	SUCCEEDED	0	1	542	-	-	-	-
201712280600	gdasecen	444555	SUCCEEDED	0	1	422	-	-	-	-
201712280600	< gdasefmn	444588	(8/8) SUCCEEDED	0	1	2445	336	0	904289	2445
201712280600	< gdasepmn	444724	(7/7) SUCCEEDED	0	1	264	81	0	72935	264
201712280600	< gdaseamn	444746	(8/9) RUNNING	0	1	311	1	0	165	311
201712280600	gfsprep	444205	SUCCEEDED	0	1	300	-	-	-	-
201712280600	gfsanal	444381	SUCCEEDED	0	1	2635	-	-	-	-
201712280600	gfsfcst	444596	RUNNING	0	0	1008	60	7349800	4381	
201712280600	< gfspost	444604	(1/11) RUNNING	0	1	107	-	-	-	-
201712280600	gfsvrfy	-	-	-	-	-	-	-	-	-
201712280600	gfsarch	-	-	-	-	-	-	-	-	-

Topics

- 1. Upcoming FV3GFS implementation for operation
- 2. FV3GFS workflow and repositories
- 3. How to create grid and orography
- 4. How to make initial conditions
- 5. How to configure an experiment
- 6. **Post processing and product generation**
- 7. Verification

jobs/rocoto/ post.sh

JGLOBAL_NCEPPOST exgfs_nceppost.sh.ecf gfs_nceppost.sh

Fcst output

**gfs.t00z.atmf120.nemsio
gfs.t00z.sfcf120.nemsio**

UPP:
vertical interpolation
Product generation

**gfs.t00z.master.grb2f120
gfs.t00z.sfluxgrbf120.grib2**

**Gaussian grid,
pressure layers
grib2**

**fv3gfs_downstream_nems.sh
fv3gfs_dwn_nems.sh**

**gfs.t00z.pgrb.1p00.f120 gfs.t00z.pgrb2b.0p25.f120
gfs.t00z.pgrb2.0p25.f120 gfs.t00z.pgrb2b.0p50.f120
gfs.t00z.pgrb2.0p50.f120 gfs.t00z.pgrb2b.1p00.f120
gfs.t00z.pgrb2.1p00.f120**

**Lat-Ion grid,
pressure layers
grib2**

Topics

1. Upcoming FV3GFS implementation for operation
2. FV3GFS workflow and repositories
3. How to create grid and orography
4. How to make initial conditions
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6. Post processing and product generation
7. **Verification**

EMC VSDB-based verification package

It performs the following verifications for NWP forecasts:

AC, RMSE, BIAS etc: model forecast statistics are first computed and saved in VSDB format; verification maps are then made to compare stats among different experiments and/or with operational forecast (up to 10 experiments)

QPF: precipitation threat skill scores over CONUS are first computed , then ETS score maps are made with Monte Carlo significance tests included.

grid-to-Obs: verifying forecasts against surface station observations (e.g. T2m and 10-m wind) and upper-air RAOBS

2D MAPS: make maps of lat-lon distributions and zonal mean vertical cross-sections of forecast s, analyses and certain observations, such as U,V,T,Q,RH,O3, T2m, Precip, etc.

Hurricane track and intensity

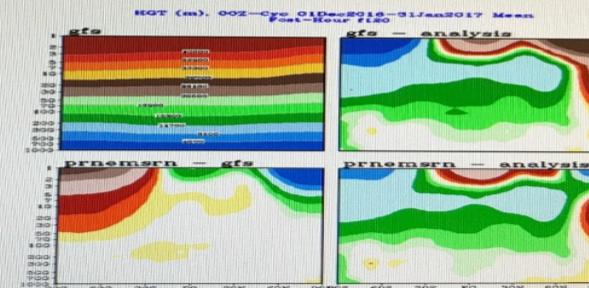
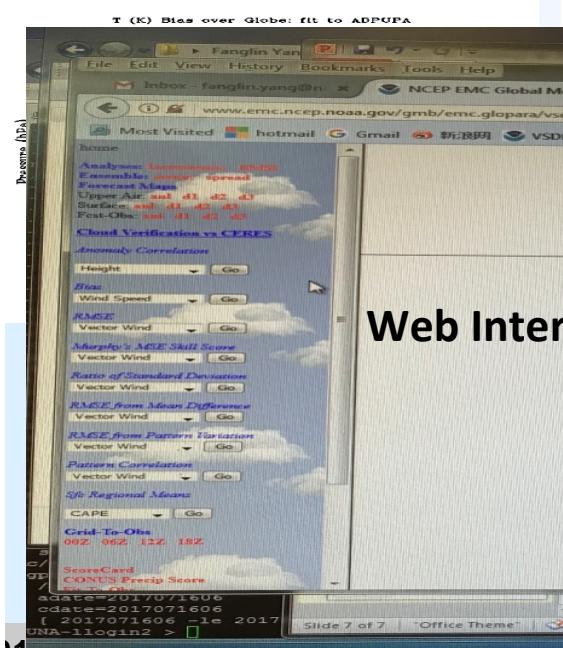
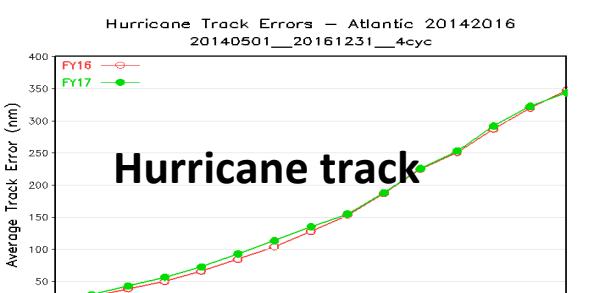
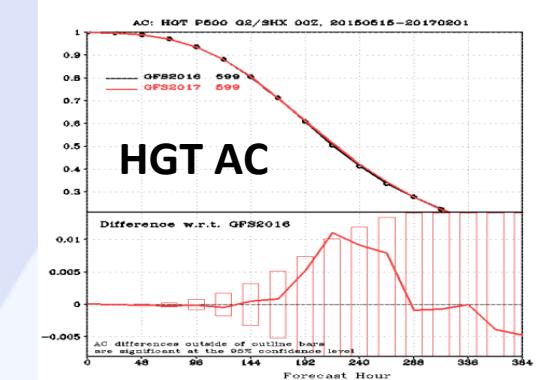
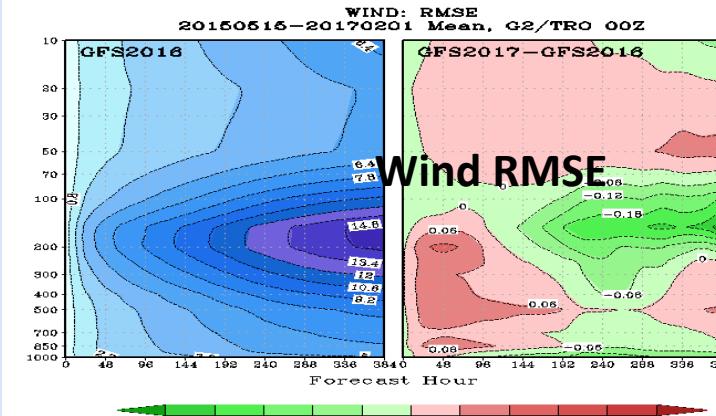
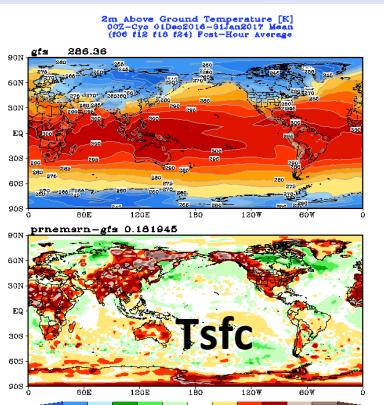
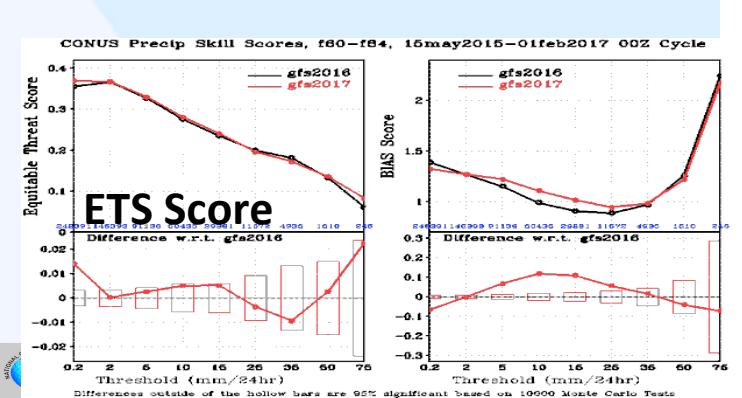
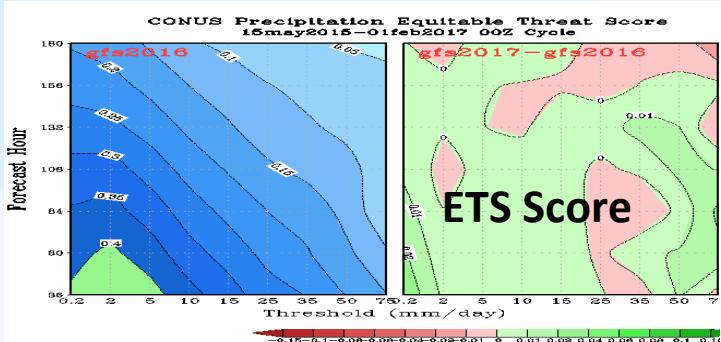
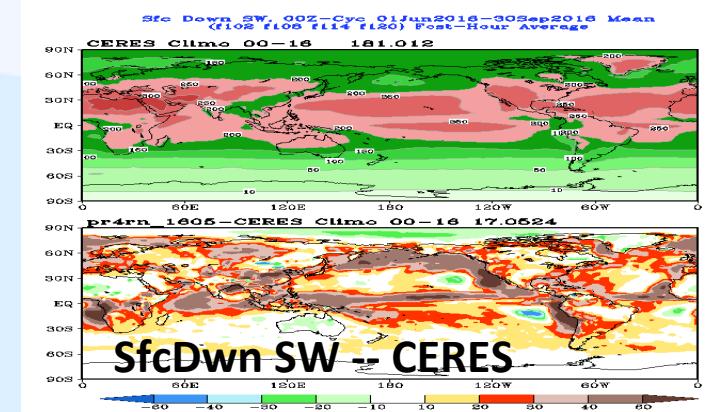
Analysis Increments; Ensemble Spreads

Scorecard -- A summary of major verification metrics

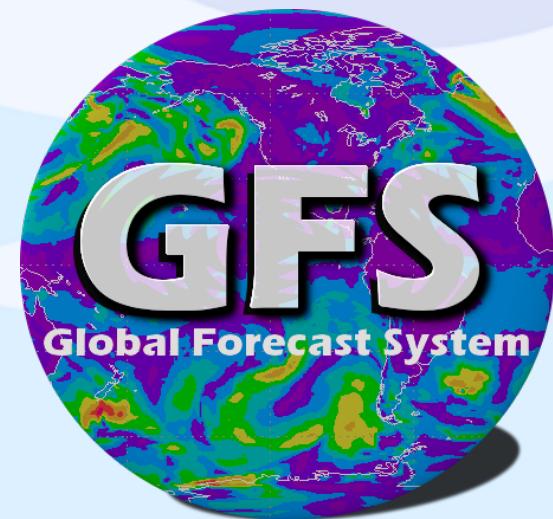
The package can be run on-the-fly as a part of the forecast system, or run offline after forecasts finish as well.

This package will be replaced by MET and MET-Viewer when they are ready

Web Interface & Sample plots:



Thank you



Resolution and Physics Grid Points

	~ Resolution	Physics Grid
C768	13km	$768*768*6 = \textcolor{red}{3,538,944}$
C1024	10 km	$1024*1024*6 = 6,291,456$
C1280	7.5 km	$1280*1280*6 = 9,830,400$
C4000	1.5 km	$4000*4000*6 = 96,000,000$

T1534 GFS (~13 km) has $3072 \times 1536 = 4,718,592$ points

Rule of Thumb : $10,000 / C\#$ is grid size

The test case is C768, L64

Resolution, Physics Grid, and Run-time on Cray
 10-d forecast, 6-hourly output, 3.75-minute time step
C768, 13km, 3,538,944 points

Hydro/ non-hydro	precision	threads	nodes	CPU (min/10day)
Non-hydro	32-bit	2	16	323
Non-hydro	64-bit	2	16	360
Non-hydro	32-bit	2	64	89
Non-hydro	64-bit	2	64	137
Non-hydro	64-bit	2	144	69
Non-hydro	64-bit	4 Hyper-threading	64	135
hydro	64-bit	4 Hyper-threading	64	95
hydro	64-bit	4 Hyper-threading	144	51



T1534 NEMS GFS (~13 km, 3072x1536), 61 nodes, 73 minutes

FV3GFS is about 1.5 ~2 times slower than NEMS GFS

Resolution, Physics Grid, and Run-time on Cray

10-d forecast, 6-hourly output, non-hydrostatic, 3.75-minute time step,

C#L63	Res	#Physics Grid (6xCxC)	Runtime (minutes) 2threads
C48	200km	13,824	32-bit, 16 nodes: 3.6
C96	100km	55,296	32-bit, 16 nodes: 7.2
C192	50km	221,184	32-bit, 16 nodes: 21.0
C384	25km	884,736	32-bit, 16 nodes: 75.7
C768	13km	3,538,944	32-bit 16 nodes: 323
C1152	8km	6,291,456	
C3072	3.5 km	9,830,400	

T1534 NEMS GFS (~13 km, 3072x1536), 61 nodes, 73 minutes

Thumb of rule : 10,000 / C# is grid size

Samples of cold start initial Conditions and Restart Files

```
gfs_data.tile1.nc gfs_data.tile3.nc gfs_data.tile5.nc      gfs_ctrl.nc  
gfs_data.tile2.nc gfs_data.tile4.nc gfs_data.tile6.nc
```

```
sfc_data.tile1.nc sfc_data.tile3.nc sfc_data.tile5.nc  
sfc_data.tile2.nc sfc_data.tile4.nc sfc_data.tile6.nc      sfc_ctrl.nc
```

RESTART

```
coupler.res      fv_core.res.nc  
fv_core.res.tile1.nc fv_core.res.tile3.nc fv_core.res.tile5.nc  
fv_core.res.tile2.nc fv_core.res.tile4.nc fv_core.res.tile6.nc
```

```
fv_srf wnd.res.tile1.nc fv_srf wnd.res.tile3.nc fv_srf wnd.res.tile5.nc  
fv_srf wnd.res.tile2.nc fv_srf wnd.res.tile4.nc fv_srf wnd.res.tile6.nc
```

```
fv_tracer.res.tile1.nc fv_tracer.res.tile3.nc fv_tracer.res.tile5.nc  
fv_tracer.res.tile2.nc fv_tracer.res.tile4.nc fv_tracer.res.tile6.nc
```

```
sfc_data.tile1.nc sfc_data.tile3.nc sfc_data.tile5.nc  
sfc_data.tile2.nc sfc_data.tile4.nc sfc_data.tile6.nc
```

What's in ICs

```
ncdump -c gfs_data.tile1.nc |grep float
  float lon(lon) ;
  float lat(lat) ;
float ps(lat, lon) ;
float t(lev, lat, lon) ;
float w(lev, lat, lon) ;
float zh(levp, lat, lon) ;
float sphum(lev, lat, lon) ;
float o3mr(lev, lat, lon) ;
float liq_wat(lev, lat, lon) ;
float u_w(lev, lat, lonp) ;
float v_w(lev, lat, lonp) ;
float u_s(lev, latp, lon) ;
float v_s(lev, latp, lon) ;
```

```
ncdump -c sfc_data.tile1.nc |grep float
  float lon(lon) ;
  float lat(lat) ;
  float lsoil(lsoil) ;
  float geolon(lat, lon) ;
  float geolat(lat, lon) ;
  float slmsk(lat, lon) ;
  float tsea(lat, lon) ;
  float sheleg(lat, lon) ;
  float tg3(lat, lon) ;
  float zorl(lat, lon) ;
  float alvsf(lat, lon) ;
  .....
  float shdmax(lat, lon) ;
  float slope(lat, lon) ;
  float snoalb(lat, lon) ;
  float stc(lsoil, lat, lon) ;
  float smc(lsoil, lat, lon) ;
  float slc(lsoil, lat, lon) ;
```

What's in RESTART files

```
ncdump -c fv_core.res.tile1.nc |grep float
float xaxis_1(xaxis_1);
float xaxis_2(xaxis_2);
float yaxis_1(yaxis_1);
float yaxis_2(yaxis_2);
float zaxis_1(zaxis_1);
float Time(Time);
float u(Time, zaxis_1, yaxis_1, xaxis_1);
float v(Time, zaxis_1, yaxis_2, xaxis_2);
float W(Time, zaxis_1, yaxis_2, xaxis_1);
float DZ(Time, zaxis_1, yaxis_2, xaxis_1);
float T(Time, zaxis_1, yaxis_2, xaxis_1);
float delp(Time, zaxis_1, yaxis_2, xaxis_1);
float phis(Time, yaxis_2, xaxis_1);
```

```
ncdump -c fv_tracer.res.tile4.nc |grep float
.....
float sphum(Time, zaxis_1, yaxis_1, xaxis_1);
float liq_wat(Time, zaxis_1, yaxis_1, xaxis_1);
float o3mr(Time, zaxis_1, yaxis_1, xaxis_1);
```

```
ncdump -c fv_srf wnd.res.tile3.nc |grep float
float u_srf(Time, yaxis_1, xaxis_1);
float v_srf(Time, yaxis_1, xaxis_1);
```

```
ncdump -c sfc_data.tile4.nc |grep double
double slmsk(Time, yaxis_1, xaxis_1);
double tsea(Time, yaxis_1, xaxis_1);
double sheleg(Time, yaxis_1, xaxis_1);
double tg3(Time, yaxis_1, xaxis_1);
double zorl(Time, yaxis_1, xaxis_1);
double alvsf(Time, yaxis_1, xaxis_1);
.....
double stc(Time, zaxis_1, yaxis_1,...);
double smc(Time, zaxis_1, yaxis_1, xaxis_1);
double slc(Time, zaxis_1, yaxis_1, xaxis_1);
double phy_f2d(Time, zaxis_2, yaxis_1, xaxis_1);
double phy_f3d_01(Time, zaxis_3, yaxis_1, xaxis_1);
double phy_f3d_02(Time, zaxis_3, yaxis_1, xaxis_1);
double phy_f3d_03(Time, zaxis_3, yaxis_1, xaxis_1);
double phy_f3d_04(Time, zaxis_3, yaxis_1, xaxis_1);
```

Model Configuration – GFDL FV3

```
#&fv_core_nml
npx      = 769
npy      = 769
npz      = 91
grid_type = -1
make_nh  = .T.
reset_eta = .F.
n_sponge = 30
nudge_qv = .T.
rf_fast   = .F.
tau       = 5.
rf_cutoff = 7.5e2
d2_bg_k1 = 0.15
d2_bg_k2 = 0.02
kord_tm  = -9
```

```
kord_mt  = 9
kord_wz  = 9
kord_tr  = 9
hydrostatic = .F.
phys_hydrostatic = .F.
use_hydro_pressure = .F.
beta      = 0.
a_imp     = 1.
p_fac     = 0.1
k_split   = 1
n_split   = 8
nwat     = 6
na_init   = 1
d_ext     = 0.0
dnats    = 1
```

```
fv_sg_adj = 450
d2_bg    = 0.
nord    = 2
dddmp   = 0.1
d4_bg    = 0.12
vtdm4   = 0.02
delt_max = 0.002
ke_bg    = 0.
do_vort_damp = .true.
external_ic = .T.
gfs_phil = .false.
nggps_ic = .T.
mountain = .F.
ncep_ic  = .F.
d_con    = 1.
```

```
hord_mt  = 6
hord_vt  = 6
hord_tm  = 6
hord_dp  = -6
hord_tr  = 8
lim_fac  = 3.0
adjust_dry_mass = .F.
consv_te = 1.
do_sat_adj = .T.
consv_am = .F.
fill     = .T.
dwind_2d = .F.
warm_start = .F.
no_dycore = .false.
z_tracer = .T.
```

Model Configuration

&gfs_physics_nml			
fhzero	= 6.	fhsqr	= 3600.
ldiag3d	= .false.	fhlwr	= 3600.
fhcyc	= 24.	ialb	= 1
nst_anl	= .true.	iems	= 1
use_ufo	= .true.	IAER	= 111
pre_rad	= .false.	ico2	= 2
ncld	= 5	isubc_sw	= 2
zhao_mic	= .false.	isubc_lw	= 2
pdfcld	= .false.	isol	= 2
		lwhtr	= .true.
		swhtr	= .true.
		cngwd	= .true.
		do_deep	= .true.
		shal_cnv	= .true.
		cal_pre	= .false.
		redrag	= .true.
		dspheat	= .true.
		hybedmf	= .true.
		random_clds	= .false.
		trans_trac	= .true.
		cnvclld	= .false.
		imfshalcnv	= 2
		imfdeepcnv	= 2
		cdmbgwd	= 3.5, 0.25
		prslrd0	= 0.
		ivegsrc	= 1
		isot	= 1
		xkzminv	= 0.3
		xkzm_m	= 1.0
		xkzm_h	= 1.0

Model Configuration

```
&gfdl_cloud_microphysics_nml
sedi_transport = .true.
do_sedi_heat = .false.
rad_snow = .true.
rad_graupel = .true.
rad_rain = .true.
const_vi = .F.
const_vs = .F.
const_vg = .F.
const_vr = .F.
vi_max = 1.
vs_max = 2.
vg_max = 12.
vr_max = 12.
```

```
qi_lim = 1.
prog_ccn = .false.
do_qa = .true.
fast_sat_adj = .true.
tau_l2v = 300.
tau_l2v = 225.
tau_v21 = 150.
tau_g2v = 900.
rthresh = 10.e-6
dw_land = 0.16
dw_ocean = 0.10
ql_gen = 1.0e-3
ql_mlt = 1.0e-3
qi0_crt = 8.0E-5
qs0_crt = 1.0e-3
```

```
tau_i2s = 1000.
c_psaci = 0.05
c_pgacs = 0.01
rh_inc = 0.30
rh_inr = 0.30
rh_ins = 0.30
ccn_l = 300.
ccn_o = 100.
c_paut = 0.5
c_cracw = 0.8
use_ppm = .false.
use_ccn = .true.
mono_prof = .true.
z_slope_liq = .true.
z_slope_ice = .true.
```

```
de_ice = .false.
fix_negative = .true.
icloud_f = 1
mp_time = 150.
```